

GLOBAL ISLAND IMAGE-MAPS (GIIM): A SET OF DIGITALLY PROCESSED MODIS IMAGES.

Nikolaos A. Soulakellis¹, Jacob Yates² and George Tataris¹

1. Department of Geography, University of the Aegean, 81100 Mytilini, Greece, Tel: +30-2510-36412, FAX: +30-2510-36448, Email: n.soulakellis@aegean.gr

2. NASA-Goddard Space Flight Center, Geodynamics Branch, Maryland, USA.

Abstract

The growing cultural, environmental, and socio-economic importance of *island regions* leads to an increasing demand for an adequate cartographic database. Land discontinuity, endemic biodiversity, remote locations, and varying spatial scales are some of the inherent characteristics of island biogeography issues that require innovative cartographic approaches.

Earth Observation from space should be considered one of the most important and reliable sources of information gathering for cartographic purposes at both global and regional levels. Satellite coverage provides the capability to observe spatial, spectral, and temporal changes of these isolated landscapes. The conversion of raster imagery into image-maps will facilitate and contribute to the multi-temporal monitoring and mapping of anthropogenic and natural phenomena of island landscapes.

This article presents the methodology followed and the results obtained by the utilization of imagery acquired by MODIS — Moderate Resolution Spectroradiometer instrument flying on TERRA and AQUA satellite systems for the creation of digital image-maps for islands of the world. These maps may contribute to the: a) sustainable development of island regions, b) effective management of coastal areas, c) monitoring, protection, and management of an island's rare resources and fragile environment, d) human protection from natural or technological disasters (tsunamis, oil spills, sea water level changes etc.), and e) development and planning of tourism, and f) land use/change monitoring.

1. INTRODUCTION

Island cartographies or *isolarii* is the term for Mediterranean map books of islands. Cristoforo Buondelmonte produced the first island book or isolario for his patron Cardinal Giordano Orsini of Rome. It was titled *Liber Insularum Archipelagi*, produced about 1420 and contained over 70 maps of Greek islands [1]. The very remoteness of the islands makes it difficult to maintain full-scale terrestrial surveys of the land use and the vegetation or land cover. In a region that is frequently ravaged by forest fires, the state of the forests would have to be monitored, and remote sensing would allow for that and systems exist already to provide for such monitoring work [1].

On 1994 Den gre J. [2] presented the potential exploitation of satellite imagery processing, interpretation and thematic information extraction for cartographic purposes. Satellite platforms, monitoring Earth from space, provide in a daily basis a vast amount of information in image format. This in turn, led to an increasing demand from environment scientists of reliable and diachronic image-maps, at multiple scales. Satellite image maps provide a synoptic and comprehensive view of the Earth's environment and as such they could be considered as a valuable environmental information source.

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MODIS is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths (see Table 1). These data improve our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. MODIS is playing a

vital role in the development of validated, global, interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment [3].

The present work focuses on this issue and presents the results obtained by developing a set of Global Island Image Maps — GIIM by taking full advantage of the capabilities offered by the nearly new MODIS — Moderate Resolution Imaging Spectroradiometer instrument.

Table 1. MODIS Technical Specifications [3].

MODIS Technical Specifications

Orbit:

705 km, 10:30 a.m. descending node (Terra) or 1:30 p.m. ascending node (Aqua), sun-synchronous, near-polar, circular

Scan Rate:

20.3 rpm, cross track

Swath Dimensions:

2330 km (cross track) by 10 km (along track at nadir)

Telescope:

17.78 cm diam. off-axis, afocal (collimated), with intermediate field stop

Size:

1.0 x 1.6 x 1.0 m

Weight:

228.7 kg

Power:

162.5 W (single orbit average)

Data Rate:

10.6 Mbps (peak daytime); 6.1 Mbps (orbital average)

Quantization:

12 bits

Spatial Resolution:

250 m (bands 1-2)
500 m (bands 3-7)
1000 m (bands 8-36)

Design Life:

6 years

2. DATA AND METHODOLOGY

NASA's MODIS Rapid Response System, have been exploited in order to select the most appropriate MODIS images covering island regions all over the world [4]. Finally, twenty-six (26) MODIS images have been selected (Figure 1) based mainly on: i. the optical quality of the available images and ii. the amount of clouds appeared into the scenes since many of them were acquired during cloudy conditions. There are still some island regions of the world that are not being covered by the existing images mainly due to image quality conditions. Such conditions are optical in nature (i.e. atmospheric haze), while other conditions are technical (i.e. line drop off)

The methodology we followed in order to develop a useful satellite image-map set covering islands all over Earth can be distinguished into the following stages (Figure 2):

- a) *Geometric correction (georeference) of the satellite images:* In order to preserve as much as possible the initial radiometric values the nearest neighbor resampling algorithm was applied for the geometric correction of all satellite data sets used in this study. This correction was carried out on the basis of digital maps in vector format provided by ESRI/Global Dataset allowing to visually associate observable features on the MODIS images such as promontories with the respective ones presented on the digital maps.
- b) *Visual enhancement of the satellite images:* Several algorithms i.e. histogram stretching, false color composite, focusing on visual enhancement of satellite images has been applied in order to produce high quality false color composite satellite image-maps.
- c) *Integration of MODIS satellite image-maps into a GIS:* The full exploitation of satellite-derived image-maps mainly requires their integration with environmental information deriving by multiple sources at multiple scales. Thus, Geographical Information Systems could be considered as an important means to perform this integration.

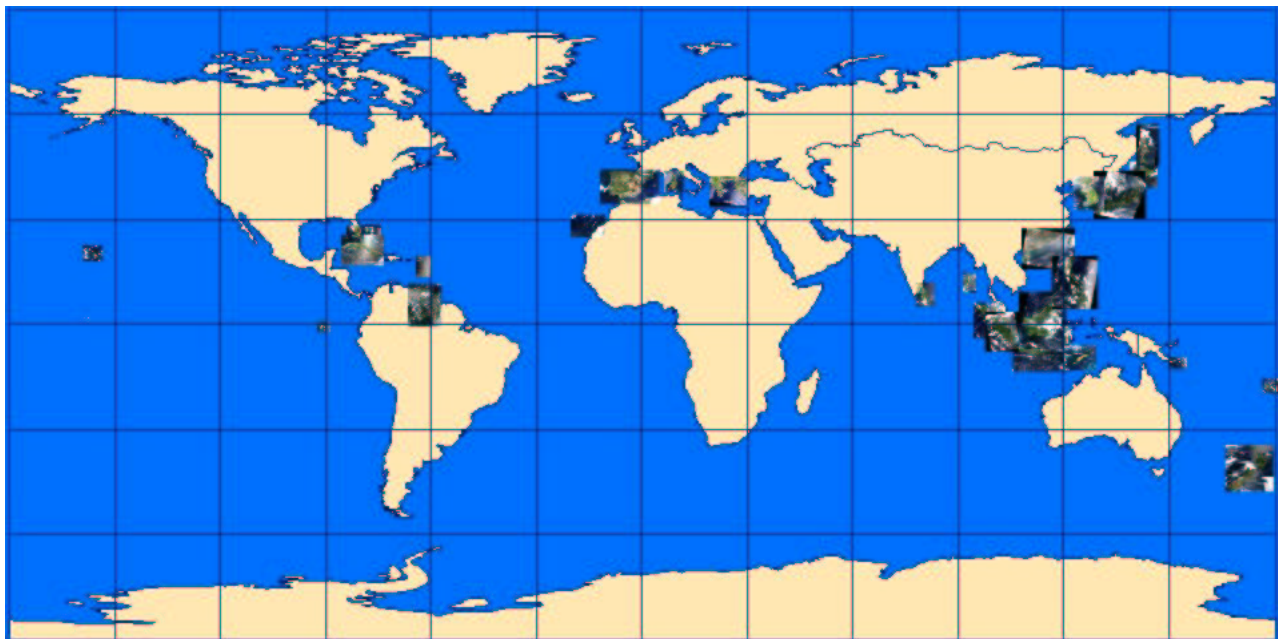


Figure 1. The geographical distribution of the twenty-six MODIS satellite image-maps that constitutes the Global Island Image map database.

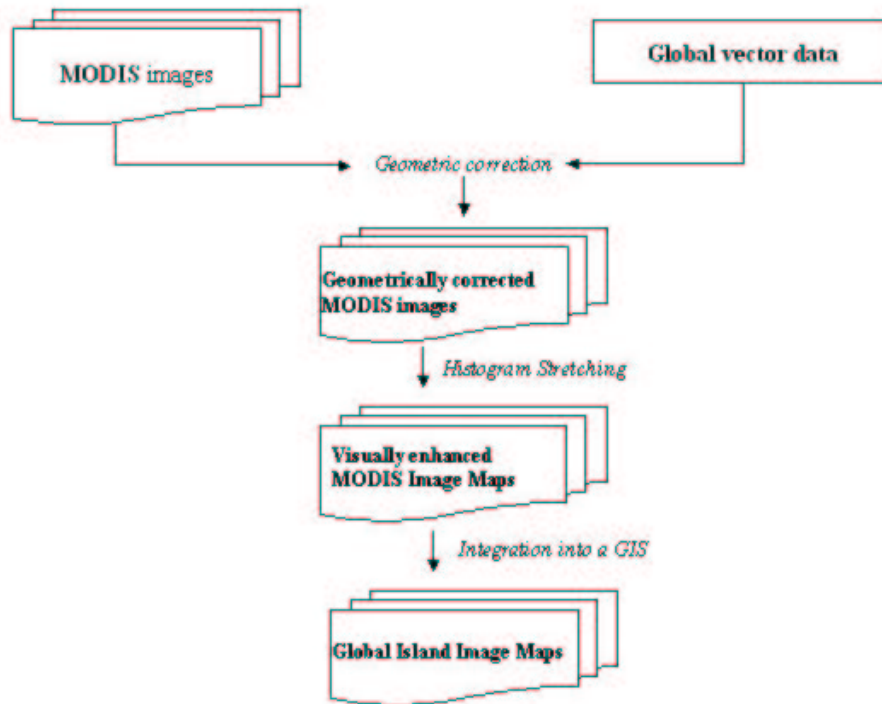


Figure 2. Flow-chart of the methodology followed from the development of the GIIM.

Table 2. List of MODIS images fulfilling the criteria of high image quality and low cloud cover.

Name	Region	Date	Time	Satellite
Adriatic sea	Mediterranean	5/18/2002	10:10 UTC	Terra
Aegean Islands	Greece	11/6/2001	10 :40 UTC	Terra
Aleutian Islands	Alaska	4/6/2002	22 :40 UTC	Terra
Andaman Islands	India	1/23/2003	04 :20 UTC	Terra
Bahamas	Caribbean	4/26/2002	15 :50 UTC	Terra
Borneo	Pacific	5/19/2002	02 :50 UTC	Terra
Canary Islands	Atlantic	1/3/2003	14 :25 UTC	Aqua
Cape Verde Islands	Atlantic	11/1/2002	12 :00 UTC	Terra
Corsica and Sardinia	Mediterranean	5/14/2002	10 :35 UTC	Terra
Cuba, Jamaica and Cayman	Carribean	6/8/2001	16 :10 UTC	Terra
Cyprus	Mediterranean	3/8/2002	08 :30 UTC	Terra
Fiji	Pacific	6/27/2001		Terra
Galapagos Islands	Pacific	3/12/2002	16 :25 UTC	Terra
Hawaii	Pacific	12/13/2002	20 :55 UTC	Terra
Hokkaido	Japan	5/30/2001	01 :20 UTC	Terra
Honshu and Shikoku	Japan	10/15/2001	01 :55 UTC	Terra
Ionian Islands	Greece	15/07/2001	10 :55 UTC	Terra
Java, Indonesia	Indonesia	5/19/2002	02 :55 UTC	Terra
Kiribati	Pacific	1/16/2002		ISS

Korea		5/13/200102 :15 UTC	Terra
Kuril Islands	Eastern Russia	5/17/200201 :10 UTC	Terra
Lesser Antilles	Carribean	8/26/200214 :50 UTC	Terra
Madagascar	Africa	4/23/200207 :15 UTC	Terra
New Zealand	Pacific	12/31/200222 :35 UTC	Terra
Southwest Japan	Japan	5/13/200102 :15 UTC	Terra

3. DISCUSSION AND RESULTS

The growing social, economic, environmental and cultural importance of *island regions* leads to an increasing demand for adequate cartographic base data with respect to its contents, graphic design and media. Especially the visualization of a large spectrum of parameters, related mainly to an island context, requires special cartographic methods and approaches. Land discontinuity, size diversity, remoteness and isolation are some of the inherent characteristics in an island context that requires innovative cartographic approaches.

Cartography via electronic atlases, interactive thematic maps, animated visualizations, web cartography etc has a significant role to play for the: a) sustainable development of island regions, b) effective management of coastal areas, c) monitoring, protection and management of island rare resources and fragile environment, d) human protection from natural or technological disasters (tsunamis, oil spills, sea water level changes etc.), e) tourism development and planning and f) land use/change monitoring.

Local authorities face several problems mainly related to socio-economic development that directly affects the environment, and effective mapping is crucial if solutions are to be found. In conjunction with the great data gathering capabilities and analytical power of remote sensing and geographic information systems (GIS), cartography, in many instances, provides the key to finding solutions.

Oceanic islands are important index indicators for climate change and landscape evolution. Island biogeography issues such as anthropogenic, lands cover, and sea-level changes are important calibration study sites for monitoring change detection at various temporal scales. By studying islands at various spatial, spectral, and temporal scales, an accurate quantitative assessment of island landscape may be realised [5]. Consequently, the development of the Global Island Image-Maps (GIIMs) may contribute to a better understanding of island environment via multi-temporal monitoring not only at regional and local scales but also at global scale.

Aegean Archipelago islands, in Greece, are characterized by active tectonics and volcanism. The integration of the equivalent MODIS satellite image-map with additional information i.e. bathymetry, geological units, volcanoes etc (Figure 3) enables to reveal the complex geodynamic processes and monitor the evolution of the area.

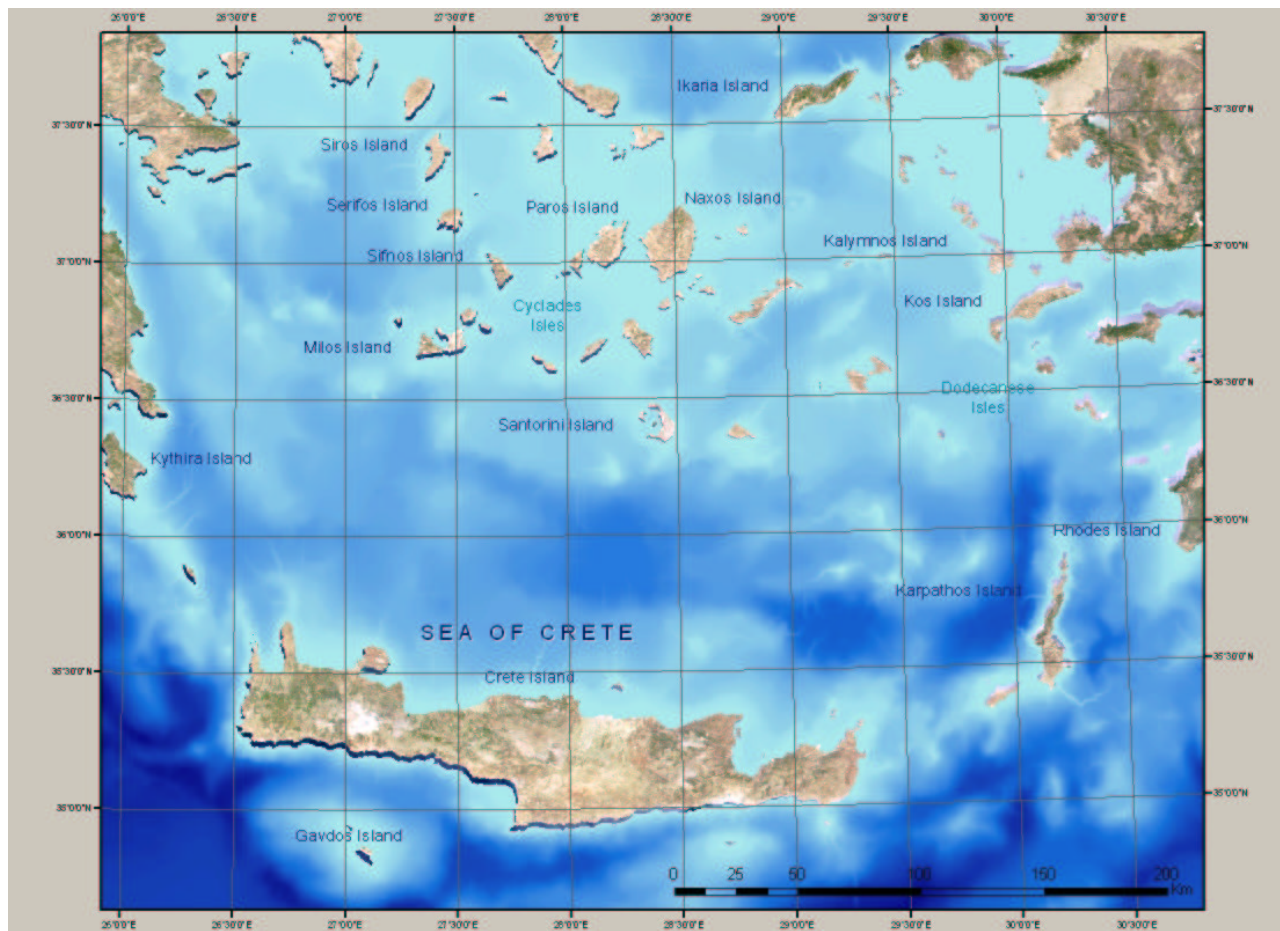


Figure 3. More than 2,000 islands comprise the Aegean Archipelago islands in Greece. MODIS image-map of southern Aegean, integrated with bathymetry data of the Aegean Sea, reveals the geodynamic and environmental setting of the islands and enables a better understanding of their origin.

4. CONCLUSIONS

Earth observation datasets are not commonly used for thematic information retrieval despite the fact that their ground sampling distances comply with requirements for local, regional and global scale mapping. The spatial, spectral and temporal features make satellite images, despite their initial land, air and ocean-mapping mission, also suitable for island environment monitoring and mapping. In the current application we use a series of MODIS-images to create image-maps of islands worldwide. Twenty-six image-maps, having high quality and low cloud cover, has been integrated into a GIS to assist their interpretation and thematic information extraction processes.

In the future, we plan to profit from the combination of spatial, radiometric and spectral characteristics of Earth Observation satellite sensors to enrich Global Island Image-map database and provide multi-scale maps of island environments worldwide. In the current application we derive only MODIS-satellite image maps as a moderate-scale image-map set.

References

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